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TEST 11 — CHILLED-WATER SYSTEM USING CENTRIFUGAL CHILLER, BUILDING AUTOMATION — DESIGN

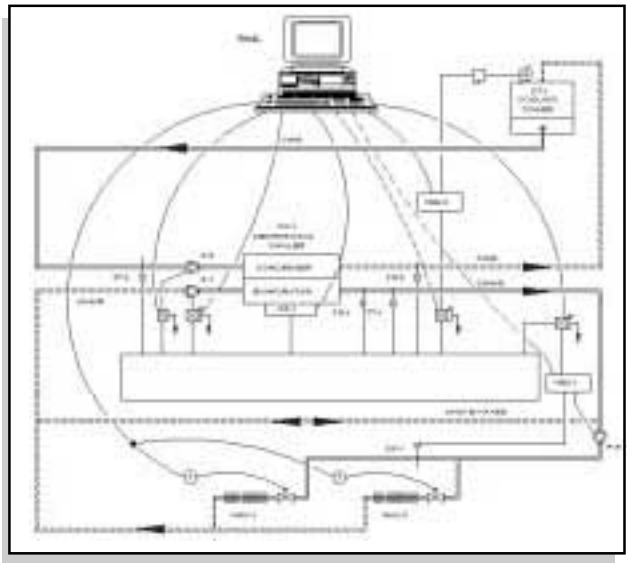
Choose the correct answer (from the choices in bold) for each of the following hvac situations, referring to the schematic diagram on this page.

1 **On-off control in the "off" position:**
Centrifugal chiller CC-1 is off, primary chilled-water pump P-1 is off, secondary chilled-water pump P-3 is off, condenser water pump P-2 is off, and "draw-through" cooling tower fan is off.

2 **On-off control in the "on" position:**
Centrifugal chiller CC-1 on-off switch at the unit control panel CP-1 is placed in the "on" position, but refrigerant process does not start until the building automation system (bas); (BAS on schematic diagram) signals the chiller to operate. Start-stop control may be based on time-of-day scheduling. (**Interlock, Power**) control signals from chiller control panel CP-1, to chilled-water pump P-1 and P-3 and condenser water pump P-2. Start all three pumps.
Chilled-water flow switch FS-1 senses flow and confirms P-1 is delivering sufficient flow for CC-1 to start. Condenser water flow switch FS-2 senses flow and confirms P-2 is delivering sufficient flow for CC-1 to start. CC-1 centrifugal refrigeration cooling process begins with (**chiller, cooling tower, bas**) measuring the electrical demand, limiting software to manage peak electrical demand and chilled-water pull-down.

3 **On-off control in the "on" position:**
With chilled-water flow, system pressure will begin to increase and differential pressure transmitter DP-1 shall begin to control the secondary chilled-water flow via variable-speed drive VSD-1 (sequence noted below). Chilled-water supply temperature control transmitter (**TT-1, TT-2**) shall be reset based on the bas computer software that will set supply temperature from a series of remote space zone thermostats (i.e., four room thermostats).
The room thermostat calling for maximum cooling shall reset discharge water temperature from a high of 62 F to a low of 55 F. Chiller CC-1 self-contained centrifugal refrigeration controls within control panel CP-1 shall be (**integrated, separated**) with the bas computer to provide current chiller status reports (i.e., outdoor air temperature, chiller diagnostic status, and system run-time, to mention a few).

4 **On-off control in the "on" position:**
Condenser water supply temperature control transmitter TT-2 may be reset from bas condenser water computer software, which will set condenser supply temperature based on condenser pressure. The bas computer (**hardware, software**) shall manage condenser water temperature setpoint by starting cooling tower fan CT-1, controlling fan speed via variable-speed drive VSD-2, and stopping fan CT- l. Based on the bas system software, condenser water supply temperature may be reset, requiring CT-1 fan to start at low speed. If condenser water supply reset schedule continues to require additional condenser cooling capacity, fan speed will (**increase, decrease**) towards maximum airflow via VSD-2. When condenser water temperature drops toward its reset schedule setpoint, CT-1 fan shall reduce speed and stop when condenser water supply temperature drops below the setpoint.



5 **Maximum cooling:**
Chiller CC-1 shall be providing maximum cooling capacity and secondary chilled-water supply pump P-3 shall be at maximum flow via VSD-1 pump speed control. Air-handling units' straight-through chilled-water valves shall be open 100%, drawing off all the chilled water for space cooling and/or dehumidification needs. Cooling tower CT-1 fan shall be operating continuously.

6 **Minimum cooling:**
Chiller CC-1 shall be providing minimum cooling capacity and secondary chilled-water supply pump P-3 shall be at minimum flow via VSD-1 pump speed control. Air-handling units' straight-through chilled-water valves shall modulate toward the closed position, reducing the need for chilled water for space cooling and/or dehumidification needs. Unused primary chilled water shall be bypassed upstream of P-3 via chilled-water bypass loop, to maintain sufficient chilled-water flow through CC-1. Cooling tower CT-1 fan shall be off.

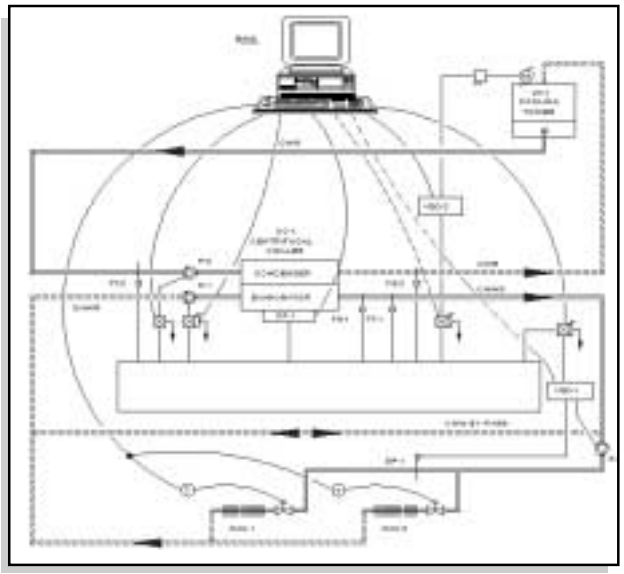
Continued on next page

If you have any questions regarding the Building Automation — Commissioning test, send your concerns, questions, and/or comments to: Rebecca Ellis, P.E., 612-546-0494 (Fax); rellis@sebesta.com *(e-mail).*

ANSWERS FOR BUILDING AUTOMATION — COMMISSIONING:
1. a) off; b) off; **2.** a) P-1, P-2, and P-3; **3.** a) reduce; **4.** a) 55 F; **5.** a) 62 F; **6.** a) lowers; b) increases; **7.** a) occupied.

TEST 12 — CHILLED-WATER SYSTEM USING CENTRIFUGAL CHILLER, BUILDING AUTOMATION — COMMISSIONING

Choose the correct answer (from the choices in bold) for each of the following hvac situations, referring to the schematic diagram on this page.



1 Turn the on-off switch at control panel CP-1 to the "off" position and set the building automation system (bas); (BAS on schematic diagram) chiller start-stop signal to "start." Verify that:
a) Pumps P-1, P-2, and P-3 are all (off, on).
b) Chiller CC-1 is (off, on).

2 Assuming time-of-day chiller scheduling, put the bas into the "occupied" mode and turn the CP-1 on-off switch to "on." Verify that:
a) Chiller CC-1 starts after pump(s) (P-1; P-1 and P-2; P-1, P-2, and P-3) starts.

3 Record the current bas electrical demand reading for chiller CC-1. Through the bas, lower the electrical demand limit to 10% lower than the current reading. Verify that:
a) The bas overrides chiller CC-1 control to (reduce, increase) cooling capacity.

4 Reset the electrical demand limit to its original value. Set one zone thermostat to a setpoint 10°F below the current zone temperature. Verify that:
a) The bas resets the CC-1 chilled-water supply temperature setpoint to (62°F, 58°F, 55°F).

5 Set all four zone thermostats to setpoints 10°F higher than their respective current zone temperatures. Verify that:
a) The bas resets the CC-1 chilled-water supply temperature setpoint to (62°F, 58°F, 55°F).

6 Reset all four zone thermostats to their original setpoints. Record current bas condenser pressure reading and condenser water temperature setpoint. Override bas condenser pressure input signal to 10% higher than the current pressure. Verify that:
a) The bas (raises, lowers) the condenser water temperature setpoint.
b) The cooling tower fan speed (increases, decreases) via VFD-2.

7 Release the bas condenser pressure input override. Verify that:
a) Chilled-water system resumes normal (occupied, unoccupied) operation.

Test 11 continued

7 Differential pressure control:
Variable-speed drive VSD-1 shall control the pump speed of P-3 based on a differential pressure-control transmitter signal that senses variations in chilled-water system pressure. Starting off at low speed, VSD-1 shall allow P-3 flow to increase based on a need to increase system pressure. When chilled-water supply pressure exceeds the DP-1 setpoint (in psig), P-3 shall begin to reduce speed via VSD-1.

HELPFUL HINTS:

There can be a wide array of (chiller, computer, building automation system) features, as well as *sequence of operations* for a centrifugal chiller. For example, a design engineer may consider the following bas options:

- Chilled-water supply temperature control transmitter TT-l reset can also be based on the bas computer software that will set chilled-water supply temperature via outdoor or return water temperature, occupied-unoccupied conditions, and/or economizer setpoint, to mention a few.
- Condenser water supply temperature control transmitter TT-2 reset can also be based on the bas condenser water computer software that will set condenser supply temperature via compressor efficiency and/or tower performance.
- Ice-making, heat recovery, and free cooling.
- Chiller status (i.e., present operating mode, active diagnostics, entering and leaving water temperatures, pressure drops, and chiller tons).
- Compressor-motor information (i.e., suction and discharge refrigerant temperature, motor winding temperature, motor line voltages, motor current draw, and (inlet vane, cylinder, head pressure) position.
- Refrigerant management (i.e., evaporator refrigerant data, condenser refrigerant data, refrigerant leak (measuring, detection), and electronically logging and documenting refrigerant concentrations in the room).
- Computerized (maintenance, system, facility) management software (i.e., planned maintenance workorder).

If you have any questions regarding the Building Automaiton — Design test, send your concerns, questions, and/or comments to:
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ANSWERS FOR BUILDING AUTOMATION — DESIGN:
2. interlock, bas; 3. TT-1, integrated; 4. software, increase; Helpful hints: building automation system, inlet vane, detection, maintenance.